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SUMMARIES OF CURRENT NORTH AMERICAN PRE-CAMBRIAN LITERATURE.[1]

SMYTH[2] reports on the crystalline rocks of St. Lawrence county, and particularly the towns of De Peyster, De Kalb, Hermon, Edwards, Canton, Russell, Potsdam, Pierrepont, and Parishville; together with points reëxamined in the towns of Gouverneur, Rossie, and Fowler, which were covered in the examination made during 1893. The crystalline limestones, for which, in a previous report, the name Oswegatchie series was suggested, form belts stretching in a northeast-southwest direction. Four belts comprise a large proportion of the crystalline limestones of the region examined. The largest, the Gouverneur belt, extends from Antwerp to probably two miles south of Canton village. Northwest of this belt another belt extends from Theresa, across Rossie and Macomb, into De Peyster. This belt is perhaps separated from the first belt by narrow strips of gneiss, along the northern boundary of Gouverneur, although the precise extent of the gneiss belts is undetermined. The third belt, the Edwards belt, to the south of the Gouverneur belt, and separated from it by a belt of gneiss, begins in Fowler, crosses Edwards, and runs out in the western part of Russell. The fourth belt, the Diana belt, south of the Edwards belt, and separated from it by gneiss, crosses the towns of Pitcairn and Diana. In general, the limestones have their greatest development in the northwestern part of the region, decreasing as the eastern and southern parts of the district are approached.

The limestone is everywhere thoroughly crystalline, ranges in color from white to dark bluish-gray, and often contains disseminated and aggregated silicates, of which the more important are serpentine and tremolite.

The term gneiss is used to include rocks ranging from acidic to basic, from fine to coarse grained, and from distinctly gneissoid, or even schistose, to entirely massive. They constitute a complex series, of rocks, differing somewhat in age, and largely, if not almost wholly, of igneous origin. Parts of this series are clearly younger than the limestones; other parts may be older than the latter formation, but there is nothing as yet to prove that such is the case. A probable exception to the latter statement is afforded by certain laminated gneisses, of limited extent, which appear to underlie the limestone, perhaps marking the base of the series.

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[1] Continued from page 205, Vol. VII., JOUR. GEOL.

[2] Report on the crystalline rocks of St. Lawrence county, by C. H. SMYTH, JR.: From the Fifteenth Ann. Rept. State Geologist, in Ann. Rept. of N. Y. State Museum, 1895, pp. 481-497.

Many of the gneisses have heretofore been believed to be sedimentary, and the evidence leading to the conclusion that they are largely igneous may be briefly summarized: There is the negative evidence of the absence of all structures pointing to sedimentary origin; the uniformity of composition and structure over wide areas, with changes by gradual transition; a common occurrence of massive cores, in every way identical with plutonic rocks; the presence of structures in the gneiss that would result from the application of pressure to igneous rocks; eruptive contacts between the abundant light-colored gneiss and the less common and older dark gneiss, together with widespread instances of inclusions of the dark gneiss in the light; the identity of the gneiss near Natural Bridge with the plutonic gabbro intrusive in the limestone; eruptive contacts at a number of places of the gneisses with the limestone.

Cushing[1] describes syenite-porphyry dikes in the northern Adirondacks. They are shown to be of pre-Cambrian age, but later than the gabbros and granites of the region. The syenite-porphyries constitute the complementary rocks to the diabases of the region, and together with them form an eruptive assemblage similar to that which characterized Keweenawan time in the Lake Superior region.

Cushing[2] describes the geology of Clinton county, New York. The pre-Cambrian succession, following Kemp, is as follows: (1) a basal gneissic series; (2) a series of schists and gneisses, with crystalline limestone; (3) igneous rocks of the gabbro type, intrusive in the first two series. All of these are overlain unconformably by Paleozoic sediments. This classification is tentative, and probably simpler than the one finally adopted is likely to be.

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[1] Syenite-porphyry dikes in the northern Adirondacks, by P. H. CUSHING: Bull. G. S. A., Vol. IX, 1898, pp. 239-256.

[2] Report on the geology of Clinton county, by H. P. CUSHING: From the Fifteenth Ann. Rep. of the State Geologist, in Ann. Rep. of N. Y. State Museum, 1895, pp. 503-573.

1. The basic gneissic series appears in the western tier of townships of the county, with the exception of Clinton, Peru, and Ausable. The gneisses comprise several varieties, varying widely in texture and composition.

2. The series of schists and gneisses, with crystalline limestone, occurs only in Black Brook township. The limestone is coarsely crystalline, and much of it is quite pure, but very often it contains much green pyroxene.

3. The gabbros occur in three areas, which are outliers of the main gabbro massive of the Adirondacks. One is in Ausable township, extending north and west of Keeseville, and is the direct prolongation northeastward of a great gabbro ridge, which comes up to Keeseville from the southwest. The second forms Rand's Hill, in Beekmantown and Altona townships, twenty miles north of the first one. The third area forms the Catamount Mountain ridge, in southwestern Black Brook township.

After the intrusion of the gabbro, and prior to the Potsdam deposition, the region was subjected to intense metamorphism, resulting in the foliation and granulation of the rocks, with or without subsequent recrystallization.

Cushing[1] maps the boundary between the Potsdam and pre-Cambrian rocks north of the Adirondacks, from the line between Clinton and Franklin counties, west across Franklin county into St. Lawrence county, to a few miles west of Potsdam.

The sequence of rocks in the region is believed to be as follows:

1. A series of gneisses of great variety of structure and composition, in which all original structures are lost, of igneous origin, and in part at least of Archean age. They seem to grade into the basic gabbros of the region; at least the gabbros present phases not to be distinguished from the gneisses.

2. The Grenville series (Oswegatchie series) comprising quartzose gneisses and schists, quartz-feldspar-biotite gneisses, dioritic, and gabbroic gneisses, and occasional bands of coarsely crystalline limestone. These rocks are accompanied by belts of gneiss, similar to the older gneiss, which seem to be interstratified with the other rocks of this series, but whose relationships are doubtful. The gneiss of the Grenville series

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[1] Report on the boundary between Potsdam and pre-Cambrian rocks north of the Adirondacks, by H. P. CUSHING: Sixteenth Ann. Rep. N. Y. State Museum, 1898, pp. 1-27. With sketch map.

differs in appearance from the older gneiss, and a considerable portion seems to be unquestionably of sedimentary origin, although dynamic metamorphism has obscured all traces of clastic structure and given the gneiss a foliation in common with the older gneisses, rendering the field relations obscure. From Parishville westward to Potsdam the Grenville series is more widely distributed, less faulted, and less completely metamorphosed, and hence with its sedimentary character less disguised, than the Grenville series farther east, probably because of its greater distance from the anorthosite intrusion. However, it seems to be beyond question that the eastern and western series are equivalent.

3. The anorthosite intrusion.
4. Later gabbros.
5. Granitic intrusions. The region was then subjected to intense dynamic metamorphism, after which occurred the intrusion of
6. Diabase and trachyte dikes.
7. Paleozoic rocks overlying unconformably all the preceding.

Kemp[1] continues his preliminary report on the geology of Essex county, N. Y., with an account of the detail geology of the individual townships. The additional observations have corroborated the conclusions reached in his previous report on this county,[2] concerning the main classification of the rocks of the area, although it is now doubtful if a sharp stratigraphic distinction can be drawn between Series (1) and (2).

Kemp[3] describes and maps the geology of the Lake Placid region in the Adirondacks of the northwest part of Essex county. Crystalline rocks of Algonkian age occupy a large part of the area. These include crystalline limestone, quartzite, granite, gneiss, and anorthosite. It is probable that some of the gneisses, and especially those associated with the limestones and quartzites, are altered sediments, and it is also probable that the gneisses with augen of labradorite are squeezed igneous rocks, but the investigation does not permit of their separation. The anorthosites have intruded and metamorphosed the limestones and quartzites, and probably some of the gneisses. It has been noted that the anorthosite frequently passes outward by gradual transition into the dark gneisses with labradorite augen. Cutting all the above rocks are trap dikes, but whether pre-Cambrian or later, is unknown.

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[1] Preliminary report on the geology of Essex county, by J. F. KEMP: From the Fifteenth Ann. Rep. of the State Geologist, in Ann. Rep. of N. Y. State Museum, 1895, pp. 579-614. With geol. maps.

[2] See Report of State Geologist of New York for 1893, pp. 433-572. Summarized in Journal of Geology, Vol. VI., 1898, pp. 528-529.

[3] Geology of the Lake Placid region, by J. F. KEMP: Bull. N. Y. State Museum, Vol. IV., 1898, pp. 51-64. With geol. map.

GENERAL COMMENT ON THE ADIRONDACK WORK

The above conclusions are of much interest as bearing on the general problems of the origin and age of the gneisses associated with the limestones of the Adirondack region. Kemp,[1] working on the eastern side of the district, has previously concluded that it does not appear certain that in the eastern Adirondack region there are any rocks older than the clastic series. As a result of field work on the eastern and western sides of the district, Van Hise[2] has held that most of the gneisses are clastic, but that a part of the red gneisses may be older than the clastic series, and therefore of Archean age. From the above summaries it appears that Kemp in his recent work still maintains the absence of the Archean. Cushing, working mainly in the northern part of the region, although overlapping Smyth's area a little way on the west, places in a lower series gneisses which he believes to be in part at least of Archean age, holds that a considerable portion of the gneisses associated with the limestones are unquestionably of sedimentary origin, and offers no evidence to show that any of the gneisses associated with the limestones are igneous and later than the limestone. Smyth, working entirely on the western side of the region, concludes that the presence of the Archean or basement gneiss has not been shown; that certain of the gneisses associated with the limestones may be sedimentary; but that the greater part of the gneisses of the district are igneous and later than the limestone. He thus agrees with Kemp on the point of the absence of the Archean.

It is to be remembered that Kemp, Cushing, and Smyth have been working in different areas. Each of them may be right as to the origin of the gneisses of his area and there may be present in the Adirondack district Archean, Algonkian, and post-Algonkian gneisses. Such is approximately the case in the Lake Superior region,

[1] Bull. G. S. A., Vol. VI., 1895, p. 251.

[2] Bull. 86 U. S. Geol. Survey, 1892, pp. 413-414, and sixteenth Ann. Rep. U. S. Geol. Survey, 1896, pp. 771-773.

where we have Archean and Algonkian gneisses and post-Algonkian granites.

While in different parts of the region the different conclusions above outlined have been reached, for the Adirondack region as a whole this much seems to have been shown. There is present a series of completely crystalline limestones and graphitic quartz-schists of sedimentary origin and pre-Cambrian age; closely associated with these are beds of graphitic and other gneisses, which are also sedimentary; cutting all the sedimentary rocks are gneisses of igneous origin, certain granites, and the great gabbro mass. That there is present a basal gneiss, while probable, has not been demonstrated. The question is still open. For much the larger part of the region also there remains for future work the discrimination of the sedimentary gneisses and the igneous gneisses of later origin.

The lithological similarity of the Adirondack sedimentary series with the Grenville series of the Original Laurentian district to the north has frequently been commented upon. In the latter district it has been possible lately to separate the sedimentary gneisses associated with the limestones from the true igneous gneisses of the Basement Complex by means of chemical analyses. The success of this method in the Original Laurentian district suggests that it may afford the best means for a satisfactory determination of the origin of the lower gneisses in the Adirondack district.

Miller[1] describes the occurrence of corundum in gneiss, syenite, and quartz-pegmatite of the Laurentian in the counties of Hastings, Renfrew, and Peterborough, in eastern Ontario.

Adams[2] reports on the geology of a portion of the Laurentian area lying to the north of the island of Montreal.

A previous report[3] summarized in this JOURNAL (Vol. VI., pp. 850-852), covers about the southeastern quarter of this area, and in a general way the conclusions reached for this southeastern area are applied to the larger area under discussion.

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[1] Economic geology of eastern Ontario, corundum and other minerals, by WILLETT G. MILLER: Report of the Bureau of Mines, Ontario, Vol. VII., 1898, pp. 207-238.

[2] Report on the geology of a portion of the Laurentian area lying to the north of the island of Montreal, by FRANK D. ADAMS: Ann. Rep. Geol. Surv. of Canada, Vol. VIII., 1897, part J, pp. 184. With geological map.

[3] Ann. Rep. Geol. Surv. of Canada for 1894, Vol. VII., 1896, part J.

The Archean geology is summarized by the author as follows:

1. The Archean rocks in this area are of Laurentian age,[1] and are in part referable to the Grenville Series and in part to the Fundamental Gneiss.

2. The Grenville Series contains gneisses, as well as limestones and quartzites, which are of aqueous origin, having the chemical composition and the stratigraphical attitude of sedimentary rocks. With these are intimately associated, however, other gneisses which are of igneous origin.

3. The Fundamental Gneiss consists largely, if not exclusively, of igneous rocks in which a banding or foliation has been induced by movements caused by pressure.

4. Both series are penetrated by various igneous masses, of which the most important are great intrusions of anorthosite, a rock of the gabbro family, characterized by a great preponderance of plagioclase. This rock is in places perfectly massive, but generally exhibits the irregular structure which is so often observed in gabbros and which is brought about by a variation in the size of the grain or the relative proportion of the constituents from place to place. In addition to this original structure, the rock almost always shows a peculiar protoclastic, cataclastic or granulated structure which is especially well seen in the foliated varieties. This differs from the structure characteristic of dynamic metamorphism in the great mountainous districts of the world, having been produced by movements in the rock-mass while this was still deeply buried in the crust of the earth and probably very hot—perhaps near the melting point.

5. The same granulated structure is also seen in all those gneisses which have been formed from massive igneous rocks by dynamic movements.

6. The fine grained aqueous rocks of the Laurentian, on the other hand, have been altered chiefly by a process of recrystallization.

7. The "Upper Laurentian" or "Anorthosite Group" of Sir William Logan does not exist as an independent geological series—the anorthosite, which was considered to be its principal constituent, being an intrusive rock, and its remaining members belonging to the Grenville Series.

8. In all cases of supposed unconformable superposition of the

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[1] In the sense of pre-Cambrian or Original Laurentian.

anorthosite upon the Laurentian gneisses, which have been carefully investigated, the unconformability is found to be due to intrusion.

9. The anorthosites are probably of pre-Cambrian age, and seem to have been intruded about the close of the Laurentian.

10. The Canadian anorthosites are identical in character with the anorthosites associated with the Archean rocks of the United States, Norway, Russia, and Egypt. The Norwegian occurrences, however, are probably more recent in age than those of Canada.

Adams and Barlow[1] give a general outline of geological work begun, but not yet finished, in the Laurentian of central Ontario, in the area comprising map sheets No. 118 and a portion of 119 of the Ontario series of geological maps, and indicate certain conclusions which seem likely to be reached concerning the origin and relations of the Grenville and Hastings series.

The Fundamental Gneiss occupies the northwestern, and by far the larger portion of the area. It consists of igneous rocks closely allied to granites, diorites, and gabbros, all showing more or less distinct foliation.

The Grenville and Hastings series are principally exposed in the southeastern portion of the area, the Grenville series appearing in a belt adjacent to the Fundamental Gneiss, and between the Fundamental Gneiss and the Hastings series.

The Grenville series is composed principally of gneisses identical in character with the Fundamental Gneiss, but it contains also, and is characterized by a small quantity of altered sediments, chiefly limestone. Some varieties of the gneissic rocks may owe their origin to the partial commingling of the sedimentary material with the igneous rocks by actual fusion. The strike of the foliation of the rocks of the series follows in a general way that of the Fundamental Gneiss. The Grenville series is believed to be a sedimentary series, later than the Fundamental Gneiss, which has sunk down into, and been invaded by, intrusions of the latter series when this was in a semi-molten or plastic condition.

The Hastings series is composed chiefly of thinly bedded limestones, dolomites, etc., cut through by great intrusions of gabbro, diorite, and granite. This series is believed to represent the Grenville series in a less altered form. That is, the Fundamental Gneiss, upon which the Hastings series was originally laid down, having at a subsequent time been softened by the influence of heat, and having under the influence of dynamic action eaten into and fretted away the overlying Hastings series, gave rise to an intermediate zone of mixed rocks which constitutes the Grenville series. The Grenville series may, however, represent only a portion of the Hastings series, and the work so far done has been insufficient to determine the stratigraphical position of this portion. It seems probable that the age of the Hastings series will be shown to be Huronian.

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[1] On the origin and relations of the Grenville and Hastings series in the Canadian Laurentian, by F. D. ADAMS, and ALFRED E. BARLOW: Am. Journ. Sci., 4th ser., Vol. III, 1897, pp. 173-180.

The Grenville and Hastings series are unconformably overlain by, and disappear to the south beneath, flat-lying Cambro-Silurian rocks.

Ells[1] gives a general account of the Archean of eastern Canada, including a review of the various classifications made by the earlier geologists, and their recent modifications. It is concluded that it is possible to reduce the great series of the so-called Laurentian rocks to two principal divisions, viz., a lower Basal or Fundamental Gneiss, in which all traces of sedimentation are wanting, and which may be regarded as representing in altered form some portion of the original crust of the earth; and a newer, secondary series, derived doubtless from the decay of the former, in which the evidences of clastic origin are manifest. On this basis the arrangement of the systems for eastern Canada would be as follows:

LAURENTIAN, NON-SEDIMENTARY

Basal or Fundamental Gneiss (Ottawa gneiss), representing in altered form the original crust of the earth, and the lowest known series of rocks; without evidence of sedimentary origin.

HURONIAN, PARTLY SEDIMENTARY AND PARTLY IGNEOUS

Grenville and Hastings series, comprising limestones, quartzites, gneisses, etc., of Ontario and Quebec, in the Ottawa district.

Schists and altered slates, chloritic and other crystalline rocks of the Eastern Townships of Quebec, and the Gaspé peninsula.

Felsitic and gneissic rocks of northern New Brunswick.

Gneiss, quartzite, and limestone, of the so-called Laurentian of southern New Brunswick, regarded as the equivalents of the Grenville and Hastings series, felsites and schistose rocks of the Coldbrook, Kingston and Coastal divisions, the apparent equivalents of the rocks of the Sutton Mountain anticlinal.

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[1] Notes on the Archean of eastern Canada, by R. W. ELLS: Proc. and Trans. Royal Society of Canada, 2d series, Vol. III, 1897, Sec. 4, pp. 117-124.

Felsitic and syenite rocks of eastern Nova Scotia and northern Cape Breton, with their associated crystalline limestones and serpentines.

CAMBRIAN

Cambrian slates, sandstones, and conglomerates.

General comment.—The succession and correlation proposed in the above papers by Adams and Barlow and by Ells are fundamentally different from the traditional one which has been held in Canada for many years. The first departure is in placing the Grenville and Hastings series as equivalent to the Huronian. Ells goes further and places with the Huronian all the sedimentary rocks of eastern Canada. This usage of the term Huronian restricts the Laurentian to the basal or fundamental gneiss. While the names are different, this is essentially the classification proposed by Van Hise in his Correlation Paper —Archean and Algonkian, in 1892. However, in place of Laurentian, he would use the term Archean. Also he would restrict the term Huronian to the rocks of the Original Huronian area and their equivalents. As it is impossible to be certain whether or not sedimentary series of eastern Canada not structurally connected with the Original Huronian are really equivalent to it, he has included the rocks above called Huronian under another name—Algonkian, a broader term covering all pre-Cambrian sedimentaries and contemporaneous eruptives, including the Keweenawan. The essential point, the existence of a non-sedimentary basal complex separated by a profound unconformity from a later pre-Cambrian series, partly sedimentary and partly igneous, is agreed upon.

Willmot[1] describes the geology of the Michipicoton mining division, which is limited on its eastern side by the 84th meridian, on the west by Lake Superior, on the south by latitude 47° 30′, on the north by latitude 48° 30′. Most of the rocks of the area belongs to the Laurentian and Huronian. The northern, eastern, and southeastern portions of the area are occupied by the Laurentian; the central and southwestern portions by the Huronian. The Laurentian is almost everywhere a fine

[1] The Michipicoton mining division by A. B. Willmot: Report of the Bureau of Mines, Ontario, Vol. VII, 1898, pp. 184–206.

grained gray gneiss, which often becomes granitic and coarser grained in texture. The Huronian rocks are most commonly massive diorites and diabases, and hornblende and chlorite-schists; less commonly, they are slates, felsites, quartzites, and sericite-slates. The Laurentian is frequently in eruptive contact with the Huronian.

In two areas, the Nipigon or Keweenawan rocks overlie the Huronian and Laurentian rocks. These areas are one two miles north of Cape Choyye and one on the peninsula of Gargantua.

Walker,[1] in 1897, describes the stratigraphy and petrology of the Sudbury nickel district of Canada. The oldest rocks of the district are gneisses of various kinds, which are regarded as of Laurentian age. Next in age to the gneisses is a belt of rocks consisting of quartzite, graywacke, amphibolite, mica-schist, phyllite, clay-slate, and altered volcanic breccia, which extends from the north shore of Lake Huron northeastward to Lake Mistassini, in the neighborhood of Sudbury, the belt being about twenty-five miles wide. The rocks of this belt are believed to be of Huronian age. The Huronian rocks have suffered severe metamorphism, and the original character of many of them cannot be made out. In and adjoining the Huronian belt are elliptical areas of later eruptive greenstone, in places intimately associated with and genetically inseparable from gneissoid and micropegmatitic granites. The nickel ore, principally pyrrhotite, occurs intimately intermingled with the eruptives, and is regarded as a concentration by differentiation from the eruptive magma. Cutting both the Huronian and the included nickel-bearing eruptives are masses of fine grained pinkish biotite-granite, sending apophyses into the surrounding rocks. This granite is found to have been intruded in two eruptions. The youngest rocks of the Sudbury district are olivine-diabases, which occur in dikes, cutting all the other rocks of the district.

Bell[2] reports on the geology of the French river sheet, which represents the country around the north end of Georgian Bay. Huronian rocks occupy the northwest corner of the sheet, and Laurentian rocks all the area to the southeast.

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[1] Geological and petrographical studies of the Sudbury nickel district of Canada, by T. L. Walker, Q. J. G. S., Vol. LIII, 1897, pp. 40–66. With geol. map.

[2] Report on the geology of the French river sheet, Ontario, by Robert Bell: Ann. Report of the Geol. Surv. of Canada for 1896, Vol. IX, 1898, Part I, pp. 29. With geol. map.

The Laurentian rocks in general resemble the Grenville series, which belong to the upper division of the Laurentian. They consist of red and gray mica and hornblende-gneisses in beds which can be traced with regularity for considerable distances, together with coarse hornblende and mica-schists and bands of quartz-rock with schistose partings. No limestones have yet been found among those rocks within the boundaries of the sheet, but in the Parry Sound district to the eastward, among similar strata, the writer has traced five bands of crystalline limestone like those of the Grenville series. The gneisses are distinctively stratified and regularly arranged in anticlinal and synclinal forms, according to the structural laws governing stratified rocks; the average angles of dip are not steep, and in general, so far as their texture is concerned, the gneisses have the characters of altered sedimentary deposits. Cutting the granites are greenstone dikes, with an east and west direction.

The Laurentian rocks northwest of the Huronian area, outside of the area of the sheet, are considered to belong to the older division of the system.

The Huronian rocks comprise quartzites, sericite-, chlorite, hornblende-, and arkose-schists, clay-slates, graywackes, and dolomites. They have a general synclinal structure. The quartzites of the ridges northwest of Killarney form the southern side of the basin, and those of the Cloche mountains the northern side. Along the southern side of the major syncline are several subordinate folds. Associated greenstones are less conspicuous than in the Huronian rocks on the Sudbury sheet to the north. Those present are more largely developed in the tract on the south side of Lake Panache than elsewhere.

In the space between the Cloche mountains and the range which runs eastward from McGregor Point to Sturgeon Lake, including Bay of Islands, McGregor Bay, and the land thence eastward to the junction of the two chains, the rocks belong to a local division of the Huronian which may, for present convenience, be called the arkose series, with its associated rocks. Structurally this area would appear to occupy the central part of the synclinal area between the above-mentioned conspicuous quartzite ranges. Although various forms of arkose or graywacke are the prevailing rocks within this space, there are in different parts of it considerable quantities of gray quartzites and fine quartz-conglomerates, mixed agglomerates and breccias, sericitic and micaceous schists, impure dolomites and eruptive greenstones.

As to the origin of these rocks, the thick unstratified and brecciated graywacke or arkose may represent consolidated masses of volcanic ashes or mud with stones, which were thrown upon the land or into shallow water, while the stratified varieties may have consisted of similar ejectamenta, thrown into deeper water where they became arranged into layers as we find them. Some of these rocks, whether stratified or otherwise, may represent volcanic products which were originally thrown into the sea in a molten or heated condition and became broken up and almost completely disintegrated.

A study of the different phases of the graywackes and their associated rocks in this region would appear to prove that the former constituted the crude material from which both the quartzites and clay-slates were derived by the modifying and separating action of water. Again, by the action of time, pressure, heat, and other metamorphosing agents upon different varieties of graywacke, some of our granites, syenites, gneisses, and possibly other crystalline rocks, were probably formed.

Solid and slaty argyllites are found along Long Lake, an expansion of the Whitefish River, and slate conglomerates occur on both sides of Bear Lake and between Cat and Leech lakes. However, these rocks do not form a large proportion of the Huronian series in this district.

Impure magnesian limestones occur in the northern part of the Bay of Islands, in the northwest part of the township of Rutherford, and north of the area of the sheet near Lake Panache.

Between the Huronian rocks on the north and the Laurentian rocks on the southeast there is a belt of red granite, the Killarney belt, running from Badgely Island to Three-mile Lake. This granite is apparently of eruptive origin, and of later age than the quartzites. All along the line of contact with the Huronian the rocks give evidence of great disturbance. Huge portions, as well as many of moderate size, have been separated from both sides and have been mingled together and intermixed with finer débris, all being cemented into a coarse breccia.

The southeastern side of the Killarney belt of granite rests against the Laurentian gneiss, except in the interval from the southern point of George Island to the entrance of Collins Inlet, where a narrow belt of partially altered, fine grained, brittle, red and sometimes gray quartzite intervenes between the granite and the water of Georgian Bay. Further northeastward, or where the granite of the Killarney belt comes into contact with the gneiss which prevails to the eastward, it is not always separated from the latter by a very distinct boundary. The rocks in some places pass into each other more or less gradually.

Barlow and Ferrier[1] discuss the relations and the structure of certain granites and associated arkoses on Lake Temiscaming. An examination of the contact of the granite and arkose shows a gradual and distinct passage of the granite into the arkose. Microscopically also there may be seen evidence of the decomposition of the feldspars of the granite, the breaking up of the feldspar and quartz, and finally the rearrangement and assortment of by water, indicating a gradual transition from the granite to the arkose.

The arkose is regarded as an Huronian sediment derived from and deposited on the granite. This is regarded as the only instance at present known in which the material composing the Huronian clastics can be clearly and directly traced both macroscopically and microscopically, to the original source from which it has been derived.

Comment.—The final statement is somewhat sweeping. Passing over the numerous instances of clear relations south of Lake Superior, it is necessary only to recall the instances close at hand, at Thessalon and Garden River, described by Irving, Pumpelly, and Van Hise, who found complete evidence of the unconformable relation between the Laurentian and Huronian, and of the derivation of the Huronian sediments from the Laurentian.

Burwash,[2] during the survey of the boundary line between the districts of Nipissing and Algoma in Canada, takes geological notes of the area traversed.

The run was made from south to north, from the upper waters of the Vermilion and Wahnipitae rivers, to within thirty-five miles of Lake Abittibi; and, with the exception of two areas of eruptive granite, the country was found to be underlain for the entire distance by Huronian rocks. The section is given in detail.

Tyrrell and Dowling[3] report on the country between Athabasca

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[1] On the relations and structure of certain granites and associated arkoses on Lake Temiscaming, Canada, by A. E. BARLOW and W. F. FERRIER: Geol. Mag., Vol. V, 1898, pp. 39–41.

[2] Geology of the Nipissing-Algoma line, by EDWARD M. BURWASH: Sixth Rep. of the Bureau of Mines, Ontario, 1897, pp. 167–184.

[3] Report on the country between Athabasca Lake and the Churchill River in Canada, by J. B. TYRRELL, assisted by D. B. DOWLING: Ann. Rep. Geol. Surv. of Canada, Vol. VIII, 1897, Part D, pp. 120 with geol. map.

Lake and the Churchill River in Canada. The area covered by the report is bounded on the south by the Churchill and Clearwater rivers; on the west by the lower portion of the Athabasca River; on the north by Athabasca Lake, Stone River, with its expansions, Black and Hatchet lakes, Wollaston Lake, and Cochrane or Ice River; on the east by the lower part of the Cochrane River, Reindeer Lake, and Reindeer River.

Laurentian rocks, including hornblende-granites, biotite granites, muscovite granites, granitoid gneisses, gabbros, and norites, are found outcropping on the Churchill River from two miles below the mouth of the Mudjatick River eastward to the mouth of the Reindeer River; thence northward they occupy most of the eastern part of the district. Further west they are followed north to Cree Lake. In the northern part of the area they occupy most of the northern shores of Athabasca and Black lakes.

As far as at present known, the Huronian is represented in this district solely by three small areas on the north shore of Lake Athabasca. The Huronian here includes quartzites, calcareous sandstones and schists, conglomerate, hälleflinta, ferruginous chlorite-schists, and other green schists.

The Laurentian and Huronian are unconformably overlain by horizontal sandstones and conglomerates, called the Athabasca sandstone, which is placed in the Cambrian. However, these sandstones are similar to the sandstones found to the north associated with quartz-porphyries, diabases, etc., like those of the Keweenawan of Lake Superior, and there is little doubt that the two sets of rocks belong to the same horizon.

Tyrrell[1] reports on an exploration of the Doobaunt, Kazan, and Ferguson rivers northwest of Hudson Bay, the northwest coast of Hudson Bay, and on two overland routes from Hudson Bay to Lake Winnipeg.

Laurentian rocks, including granites, diorites, and granite and diorite gneisses, occupy a large part of the region crossed by the three main lines of travel — the Doobaunt River and Chesterfield Inlet, the Kazan and Ferguson rivers, and the west coast of Hudson Bay,— although their precise extent is unknown.

The Huronian rocks include three more or less distinct groups, the Marble Island quartzites, the greenish quartzites and graywackes, and the more or less highly altered and often schistose diabases and gabbros. The largest area of Huronian is found along the coast of Hudson Bay from Baker's Foreland south to a point forty-five miles north of Cape Esquimaux, and inland for seventy miles up the Ferguson River. Other areas are found between Schultz and Baker lakes, near Lake Angikuni, near Kasba and Ennaidai lakes, the north shore of Doobaunt Lake, and the east shore of Wharton Lake.

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[1] Report on the Doobaunt, Kazan, and Ferguson rivers, and on the northwest coast of Hudson Bay, by J. B. TYRRELL: Ann. Rep. Geol. Surv. of Canada, Vol. IX, 1898, Part F, pp. 218. With geol. maps.

The Huronian rocks are overlain unconformably by the Athabasca sandstone. As this sandstone is older than the flat-lying Cambro-Silurian limestone, and unconformably above the Huronian, it is assigned to the Cambrian, although no fossils were found in the formation. Lithologically the whole terrane presents a remarkable resemblance to the red sandstones and Cambrian quartz porphyries of the Keweenawan rocks of Lake Superior, and the two terranes are regarded as holding essentially similar positions in the geological time scale.

Low[1] reports on his explorations of the Labrador Peninsula, along the East Main, Koksoak, Hamilton, Manicuagan, and portions of other rivers. Laurentian rocks occupy nine tenths of the area of the Peninsula. They include gneisses and schists, some of clastic origin, some of eruptive origin. The clastic portion is in nearly all cases the oldest.

The Huronian rocks comprise beds of arkose, conglomerate, limestone, shale, slate, sandstone, chert, quartzite, mica-schist, and eruptives, in part at least contemporaneous with, and at present represented by, schists characterized by chlorite, epidote, altered hornblende, hornblende, sericite, and hydromica; also diabases, diorites, and various granites. They occur in two large areas and several small ones. The large areas are along the East Main River from near the mouth inland for 160 miles, and the area of the large lakes southwest of Lake Mistassini.

The Laurentian and Huronian rocks are overlain with strong unconformity by a series of rocks classified as Cambrian, comprising arkose, sandstone, limestone, dolomite, felsitic shale, argillite, and argillaceous shale, together with gabbro, diabase, fine grained, decomposed traps, and volcanic agglomerates. The fine grained traps are interbedded with the clastic rock. No acid eruptives appear. On the east coast of Hudson Bay and at Chateau Bay near the eastern entrance of the Strait of Belle Isle, some of the traps have formed overflows on the surface, and are now represented by dark green, fine-grained melaphyres having large amygdaloidal cavities filled with quartz and agate. No fossils have been found in these supposed Cambrian rocks and their precise age and equivalency can only be conjectured. However, the mode of occurrence of thick beds of magnetic iron ore overlain by cherty, nonfragmental carbonates in this series, closely resembles that of the iron ores of the Lake Superior region described by Irving, Van Hise, and others. This, with other characters of resemblance, renders it almost certain that the two developments represent the same period, or, in other words, that the Animikie rocks of Lake Superior, assumed to be Lower Cambrian, are equivalent to the rocks here described as Cambrian in Labrador.

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[1] Report on explorations in the Labrador Peninsula, along the East Main, Koksoak, Hamilton, Manicuagan, and portions of other rivers, in 1892, 1893, 1894, and 1895, by A. P. Low: Ann. Rep. Geol. Surv. of Canada, Vol. VIII, 1897, Part L, pp. 387. With geol. maps.

Low[1] reports on a traverse of the northern part of the Labrador peninsula, from Richmond Gulf to Ungava Bay. Laurentian rocks occupy the greater part of the area. These are chiefly granites, more or less foliated. They are of different ages, but, except in a few cases, they cannot be discriminated. Cutting them are intrusive diabases.

Intimately associated with the granites is a series of more or less quartzose mica-gneisses and mica-schists, interbanded with hornblende-schists and hornblende-gneisses ; and at times with quartz-magnetite gneiss. These gneisses and schists are supposed to represent a bedded series of rocks somewhat similar to the Grenville series. While most of the schists are thus probably very ancient, others may be of the same age as the Cambrian.

Cambrian rocks were met with along the east coast of Hudson Bay, to the northward of Cape Johns, and on the Larch River from its junction with the Kaniapiskau upwards for thirty miles. A section examined on the east side of Castle peninsula, on the north side of the outlet of Richmond Gulf, presents rocks closely resembling the Mesnard quartzites and the Kona dolomites of the Lower Marquette series of the south shore of Lake Superior, capped by a later outflow of trap, classed as Algonkian by Van Hise.

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[1] Report on a traverse of the northern part of the Labrador peninsula, from Richmond Gulf to Ungava Bay, by A. P. Low: Ann. Rep. Geol. Surv. of Canada for 1896, Vol. IX, 1898, Part L, pp. 1-43. With geol. map.

Comments.—In the explorations by Tyrrell and Low, considering the time available and the ground covered, the determination of the geological series was necessarily of the most hasty nature. Nothing but the roughest petrographical discriminations could be made, and no structural work was possible. Their terms Laurentian, Huronian, and even Cambrian, therefore, indicate only the broad petrographical features of the rocks traversed, and do not stand for well defined series equivalent to the series so named to the south.

Following the usage of many of the Canadian geologists, the Cambrian is made to include rocks supposedly equivalent to the Cambrian, Keweenawan, and Animikie of the Lake Superior region, and Low carries it down even to include formations similar to Lower Marquette formations of the Lake Superior country. In the Lake Superior region, where most thoroughly studied, the Keweenawan and Huronian formations are separated from each other and from the Cambrian by well marked unconformities, unconformities uniformly recognized by geologists who have done close work in this region. These unconformities have been recognized also in other parts of North America. If the rocks above called Cambrian are really equivalent to the various Lake Superior series mentioned, then the extension downward of the Cambrian, across well established unconformities, to include such series, has no reasonable basis. However, in view of the scanty observations and the absence of connecting structural work, any correlation at present is little more than a suggestion, and for this reason it would be better to give the formations local names, as was done by Tyrrell in the case of the Athabasca sandstone. Thus would be avoided the confusion arising from the misuse of well defined and well established terms like Cambrian, Keweenawan, and Huronian.

Bailey[1] reports on the geology of southwest Nova Scotia. Cambrian rocks devoid of fossils occupy a large part of the area. The succession is, in ascending order, as follows:

I. Quartzite Division.
  (*a*) Heavily bedded bluish quartzites, alternating with much thinner beds of argillite.
  (*b*) Greenish-gray sandstones or quartzites, somewhat chloritic and less massive than in (*a*), and alternating with slates which are arenaceous below but become progressively more argillaceous above.

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[1] Report on the geology of southwest Nova Scotia, by L. W. BAILEY: Ann. Rep. Geol. Surv. of Canada, Vol. IX, 1898, part M, p. 154. With geol. map.

II. Banded Argillite Division.
  (*a*) Greenish-gray slates, becoming bluish or light gray, and passing upwards into
  (*b*) Purple slates, marked in the lower beds by pale, yellowish-green seams, with faint bedding lines, which are wanting in the higher beds.
  (*c*) Bluish-gray and gray slates, often with cloudings of green, purple, lilac, buff, or yellow, in places exhibiting a conspicuous banding or ribboning of the beds.
III. Black Slate Division.
  Black, with some blue or gray slates, often studded with cubes of pyrites, and very rusty-weathering.

Comment.—Here again the Cambrian has been extended downward to cover rocks, devoid of fossils, which have been mapped as Algonkian by Van Hise.[1]

Dawson[2] presents a brief note on Cryptozoon and Archæozoon found in the pre-Cambrian. A general discussion is given of the biological affinities of the Cryptozoon and Archæozoon, and descriptions are quoted of younger forms which may be the successors of the pre-Cambrian forms.

Dawson,[3] in an account of the physical geography and geology of Canada, sketches the distribution and characters of the pre Cambrian rocks.

Dawson[4] gives a general account of the pre-Cambrian rocks of Canada. This is largely a discussion of pre-Cambrian classification and nomenclature, based on a review of early and recent work on the pre-Cambrian of Canada, and will, therefore, not be fully summarized. A few of the more important conclusions may, however, be mentioned.

The Laurentian still includes both Fundamental Gneiss and the Grenville series.

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[1] Bulletin 86, U. S. Geol. Survey, Pl. V. Sixteenth Ann. Rept., Pl. CVIII.

[2] Note on Cryptozoon and other ancient fossils, by SIR WILLIAM DAWSON: Canadian Record of Sci., Vol. III, pp. 203–219.

[3] The physical geography and geology of Canada, by G. M. DAWSON: Handbook of Canada, issued by the Publishing Committee of the Local Executive of the British Assoc., Toronto, 1897.

This is largely a general summary of the present state of knowledge concerning the geology of Canada, and will therefore not be fully reviewed.

[4] Presidential address to the geological section of the British Association for the Advancement of Science, by G. M. DAWSON: Proc. Brit. Assoc. Adv. Science for 1897, Section C, p. 13

The Huronian proper, under whatever local name it may be classed, still remains a readily separable series of rocks.

The Upper Laurentian, Labradorian, Norian, or anorthosite group is found to consist essentially of intrusive rocks, later in age than the Grenville, but in all probability pre-Paleozoic.

The general tendency in our advance in knowledge appears to be in the direction of extending the range of the Paleozoic downward, whether under the old name of Cambrian, or under some other name, applied to a new system defined, or likely to be defined, by a characteristic fauna; and under Cambrian, or such new system, if it be admitted, it is altogether probable that the Animikie and Keweenawan rocks must eventually be included.

The introduction of the term Algonkian, proposed to include the recognizable sedimentary formations below the Olenellus zone, and their igneous equivalents, is believed to be a backward step, for the following reasons: It detaches from the Paleozoic great masses of conformable and fossiliferous strata beneath an arbitrary plane and unites these under a common systematic name with other vast series of rocks, now generally in a crystalline condition; it includes as a mere interlude, what, in the region of the Protaxis, is one of the greatest gaps known to geological history; and it does not in the least degree remove the difficulty found in defining the base of the Grenville series.

Comment.—The statements that there is a general tendency to extend the term Paleozoic downward as our knowledge advances, and that the introduction of the term Algonkian is a backward step, would not be agreed to by the United States geologists. However, this subject is too complex to be discussed in the space at our disposal. Those interested are referred to Bulletin 86 of the U. S. Geol. Survey, and to the Principles of North American pre-Cambrian Geology in the Seventeenth Annual Report of the U. S. Geol. Survey.

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